

Vascular access for acute haemodialysis

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SUMMARY Vascular access for acute haemodialysis was required on 29 occasions in 26 children over a six year period. Comparison was made of the forms of vascular access employed, these being the Scribner shunt, the Hickman line, and percutaneous polyvinylchloride cannulae. The Hickman catheter was used to provide vascular access in 17 patients (mean age 8.8 years (range 2.5–16 years) and mean weight 25.5 kg (range 7.7–60 kg)) and allowed adequate haemodialysis to occur. Only one catheter had to be removed because of infection, and no other serious complications were encountered. These results show the superiority of the Hickman catheter as vascular access for acute haemodialysis in children.

Haemodialysis is now practised widely in the management of renal failure in children,^{1–3} in spite of the problems of creating vascular access.⁴ For long term haemodialysis, arteriovenous shunts—for example, Brescia shunts⁵—and internal fistulae—for example, the use of a saphenous vein loop⁶—can be created successfully using microvascular techniques. These forms of access have the disadvantage that they require between six and eight weeks to mature before they are available for use. There are, however, a number of children who require acute haemodialysis—those with acute renal failure in whom acute peritoneal dialysis is not feasible and those undergoing long term dialysis in whom there is a failure of established vascular access or peritoneal dialysis. While internal fistulae using polytetrafluoroethylene grafts may be used to provide acute access in these children, such grafts have a high incidence of thrombosis, infection, and pseudoaneurysm formation.^{4,7,8} For these reasons, vascular access for acute haemodialysis usually requires some form of external device.

In the Manchester paediatric renal unit it had been the practice until 1981 to insert an external arteriovenous fistula (Scribner) to provide access in these children. Since that time the use of siliconised right atrial catheters (Hickman⁹) has been the preferred mode of access.

This study reviews the relative merits of these forms of vascular access for acute haemodialysis in children.

Materials and methods

A review was made of all children in the regional

paediatric renal/dialysis unit (based in our two hospitals) who underwent acute haemodialysis during the period 1979–86.

A record was made of the indications for dialysis, the type of access used, the duration of dialysis, and the complications encountered. Three different forms of vascular access were employed, these being the Hickman catheter, the Scribner shunt, and percutaneously inserted venous and arterial lines (used for a small number of children only).

Hickman lines. Three different varieties of the Hickman type catheter were used, depending on the size of the patient: (1) the Broviac catheter (Evermed); (2) the Hickman catheter (Evermed); and (3) the Francis catheter (Kimal). These catheters had internal diameters of 1.0, 1.6, and 2.6 mm and external diameters of 2.2, 3.2, and 4.8 mm, respectively. All these catheters were made of silicone rubber and were of variable length, with a Dacron cuff for subcutaneous fixation and a Luer's connection at one end. These catheters were inserted in an open manner.

Under general anaesthesia a skin crease neck incision was made above the medial end of the clavicle. The catheter was inserted into either the external jugular vein, if of adequate size, or else the internal jugular, through a purse string suture of 6/0 Prolene in the side of the vein. The catheter was tunnelled subcutaneously to the anterior chest wall and the length of the catheter determined so that the tip of the catheter lay in the upper part of the right atrium and the Dacron cuff midway between the catheter entry point on the chest wall and the insertion site of the catheter into the vein. A chest x

ray was performed on the operating table to ensure correct positioning of the catheter tip, and the neck wound was closed with Dexon. The catheter was used for a single needle dialysis. Between dialyses, 3 ml of heparinised saline was injected into the catheter and a cap placed onto the Luer's connection. These catheters were also used as vascular access for sampling and infusion. Catheter entry sites were cleaned and dressed daily using Hibidil followed by dry povidone iodine spray and Mepore dressing, ensuring that no adhesive came into contact with the catheter. Bacteriological swabs of the catheter entry site were taken weekly. Catheters were removed by simple traction under sedation or a light general anaesthetic.

Scribner shunts. These shunts formed an arterio-venous fistula in which blood flowed from a cannulated artery through an external silastic tube into a cannulated vein. They were inserted most commonly in the groin, utilising the superficial femoral artery and the long saphenous vein.

Other sites used for Scribner shunts included the posterior tibial artery/long saphenous vein (two cases) and the radial artery/cephalic vein (one case).

Miscellaneous group. Two children were dialysed through percutaneously placed polyvinylchloride (PVC) subclavian lines and two through percutaneously placed PVC arterial cannulae, with the venous return being through cannulae in the external jugular and long saphenous veins.

Dialysis details. All children were dialysed using the Gambro flat plate parallel flow dialyser of the following sizes: Mini-mini Minor, 0.1 m²; Mini Minor, 0.28 m²; Minor, 0.51 m²; Optima 17, 1.1 m²; and Optima 11.5, 1.1 m². Paediatric lines with a total priming volume of 56 ml were used and latterly lines with a priming volume of 33 ml were used for children weighing less than 15 kg. All but one of the patients were dialysed using a Redy machine, the one exception using the AK10 Double Pump System.

Results

Vascular access for acute haemodialysis was required on 29 separate occasions in 26 children during the period studied. Eight children had Scribner shunts inserted, 17 had Hickman type lines inserted, and four were dialysed through miscellaneous percutaneous lines.

The mean age of these children at the time of dialysis was 8.1 years, with a range of 9 months to 17 years, and mean weight was 26.7 kg, with a range of

Table 1 Mean ages and weights of the patients according to type of access used

	Type of access		
	Scribner (n=8)	Hickman (n=17)	Miscellaneous (n=4)
Age (years)	6.0	8.8	8.5
Range	0.8-17	2.5-16	2-15
Weight (kg)	25.7	25.6	30.7
Range	8.5-49	7.7-60	11.8-52

7.7 to 60 kg. The distribution of age and weight in the three access groups is shown in Table 1. Scribner shunts provided dialysis flow rates of 75 to 200 ml/min, using dialysis plates of between 0.28 m² and 1.1 m². Of the 17 Hickman type lines, one Broviac catheter was inserted into a child weighing 7.7 kg, giving a dialysis flow rate of 50 ml/min, seven Hickman catheters were inserted into children weighing from 10.1 to 16.7 kg, giving a dialysis flow rate of 75 to 100 ml/min, and nine Francis catheters were inserted into children weighing more than 18 kg, giving a dialysis flow rate of 100 to 200 ml/min. The Broviac catheter used a dialysis plate of 0.1 m², the Hickman catheters used plates of 0.28 to 0.51 m², and the Francis catheters used plates of 0.51 to 1.1 m². The miscellaneous cannulae provided dialysis flows of between 75 and 200 ml/min, using dialysis plates of 0.28 to 1.1 m².

Indications for acute haemodialysis. Acute renal failure was the commonest indication for acute haemodialysis, occurring in 21 cases. The causes of acute renal failure included seven cases of haemolytic uraemic syndrome, seven cases of peritonitis and septicaemia, five cases where acute renal failure developed in patients with chronic renal problems, and two cases of transplant failure. Of these 21 cases, acute peritoneal dialysis was attempted in four but failed due to poor drainage or subcutaneous tracking of fluid, or both. Of the remaining 17 cases in this group, acute peritoneal dialysis was thought to be inadvisable because of recent laparotomy and the presence of abdominal drains in 10 cases, previous abdominal surgery and known peritoneal adhesions in six, and anticipated bilateral nephrectomy in one.

Acute haemodialysis was performed in eight patients on long term dialysis for chronic renal failure. Five of these patients had suffered recurrent peritonitis while receiving long term peritoneal dialysis and three suffered clotting of established vascular access during long term haemodialysis. Acute peritoneal dialysis was attempted in one of this latter group but failed due to catheter blockage,

while the remaining two patients had known intraperitoneal adhesions.

Dialysis details. Table 2 shows the mean number of dialyses and the time in situ of each type of access. Hickman lines remained in situ longer and were used for more dialyses than either of the other two types of access.

Both the Hickman catheters and Scribner shunts were found to provide adequate access for efficient dialysis, with satisfactory blood urea clearance. In six cases (four Hickman and two Scribner) patients who were anephric or anuric were adequately maintained for a mean of 69 days (range 35 to 120 days), confirming the efficiency of dialysis using these forms of vascular access. Complications of each of the types of access were recorded and are summarised in Table 3. Ten episodes of complications were recorded with Scribner shunts, two of these being severe haemorrhage after accidental disconnection of the shunt. Surgical alteration and repositioning of the shunts was required in two cases, and in two cases ischaemic changes in the limb

Table 2 Mean No of dialyses and time in situ for the three types of access

	Type of access		
	Scribner	Hickman	Miscellaneous
Duration of access (days)	20.8	86.1	8.5
Range	2-63	1-171	3-24
No of dialyses	12.3	32.1	6.5
Range	2-36	1-88	2-18

Table 3 Complications of the three types of vascular access employed

Complications (episodes)	Type of access		
	Scribner	Hickman	Miscellaneous
Bleeding	2	0	0
Clotting	5	1	1
Inadequate flow	0	1	1
Infection	1	5	0
Limb ischaemia	2	0	0
Surgical alterations	2	5	0
Total	12	12	2
Complications/ access days (%)	7.2	0.8	5.8
No of complication free access routes	2	9	3
Mean days in situ of complication free access	5	41.5	10

Table 4 Reasons for stopping acute dialysis through access according to type of access employed

	Type of access		
	Scribner	Hickman	Miscellaneous
Failure of access	2 (25%)	1 (6%)	0
Establishment of permanent access/ peritoneal dialysis	0	5	0
Death	3	1	1
Recovery of renal function	3	6	2
Transplant	0	4	1

were noted during dialysis. Neither of these children had permanent limb ischaemia after removal of the shunt. Two Scribner shunts were problem free, but these remained in situ for only four and six days, respectively. Although five episodes of infection occurred in the group with Hickman lines, four of these were minor and readily treated with antibiotics. The fifth case of infection caused episodes of bacteraemia and the catheter had to be removed. This occurred in an immunosuppressed patient receiving prednisolone and azathioprine, with a focus of staphylococcal infection on her leg before the Hickman catheter was inserted. The staphylococcus isolated from the leg was the same phage type as that isolated from the removed catheter. Of the five surgical repositionings in this group four occurred in the same patient, in whom it was very difficult to maintain adequate flow from the catheter. The reasons for this are unknown. Few problems were encountered in the miscellaneous group, although only one of these patients had haemodialysis for more than four days.

Table 4 shows the reasons for stopping haemodialysis through the vascular access. Dialysis had to be stopped because of failure of access in two cases using Scribner shunts and one using a Hickman line.

Discussion

In spite of the efficacy of peritoneal dialysis, acute haemodialysis will remain an integral part of the management of renal failure in children. Polytetrafluoroethylene grafts provide the only means of permanent internal access that can be used soon after insertion, but these grafts have a high incidence of complications. External means of access are likely, therefore, to remain the preferred route for the foreseeable future. Scribner shunts have been used in the past to provide acute vascular access and provide an adequate blood flow for efficient dialysis. They have the advantage that they allow two needle

dialysis. As this study has shown, however, the Scribner shunt does have some problems. In particular, the arrangement of the external loop makes the shunt prone to accidental disconnection (25% in this series), leading to severe haemorrhage.¹⁰ In addition, the shunts are prone to clotting after repeated use (occurring in five cases (63%) in this series) and require a degree of patient immobility and often inpatient nursing care. Removal of these shunts often leads to obliteration of the superficial femoral artery, the late sequelae of which are unknown. Similar problems with Scribner shunts have been recorded in other series.⁶

By comparison, Hickman lines are fairly easy to insert and, being venous and with a Luer's connection, are less prone to accidental disconnection. These lines had fewer complication episodes per catheter day than the Scribner shunts (0.8% compared with 7.2%). While infection has often been quoted as a common problem with indwelling central venous lines, this was not reflected in this study. Factors relating to the relative lack of infective complications include the Dacron cuff on the Hickman catheter, which stimulates fibrosis and prevents the spread of infection along the track of the catheter,^{6 11} the formation of an adequate subcutaneous tunnel, and the careful attention to the dressing of the catheter entry site. Similarly, clotting of these lines was not a major problem, reflecting the advantage of using silicone rubber. The low rate of thrombus formation in silicone rubber catheters compared with PVC catheters has been shown elsewhere.¹² Once in situ Hickman catheters had a fairly long life span, which avoided the need for the urgent formation of a permanent shunt and allowed time for arteriovenous shunts to mature. Other series have also described the long life span of the Hickman type catheter—for example, Vasmant *et al* reported an average time in situ of 48 days and a maximum time of five months.¹³ Patients and parents were taught to care for the catheter and were often allowed home with the catheter in situ to continue haemodialysis on an outpatient basis. These catheters provided useful vascular access for other purposes, thus freeing the child from multiple venepunctures.

Other studies have confirmed these advantages of the Hickman catheter for acute haemodialysis^{4 11 13 14} and its relative lack of complications compared with the Scribner shunt.⁴ The chief disadvantage of the Hickman catheter is that it allows only single needle dialysis, although this problem may be circumvented using a double pump system.⁶ Vasmant *et al* described the insertion of double lumen Hickman catheters, each channel having an internal diameter of 1.6 mm, in six

children in whom two needle dialysis was then performed, using the Hickman catheter as the 'arterial' line.¹³ In all patients except one adequate flow was obtained from the Hickman line for satisfactory dialysis. The type of catheter used (Broviac, Hickman, or Francis) was dependent on the size of the patient and the desired flow, a point emphasised by Mahan *et al*, who found that the 1.6 mm diameter Hickman line did not provide adequate flow for dialysis in children bigger than 13 kg.⁴ In this study a child who weighed 16.7 kg was successfully dialysed through a similar catheter. It is recommended that the Francis catheter, with an internal diameter of 2.6 mm, should be used for children weighing more than 15 kg.

The miscellaneous group had dialysis performed through assorted percutaneous cannulae in very sick children. While these provided adequate short term access in this and other series,¹⁵ they are unsuitable for longer term use.¹⁴ Even in these sick children it is suggested that the Hickman catheter (which may be inserted in the intensive care unit) is the preferable form of vascular access.

Conclusions

It is concluded that the Hickman right atrial catheter is the preferred means of vascular access for acute haemodialysis in children, because of its ease of insertion, relative lack of complications, and durability. It provides an adequate route for efficient dialysis provided that the correct size of catheter is employed, based on the patient's weight. In these respects it is superior to both the Scribner shunt and to percutaneously placed PVC catheters.

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